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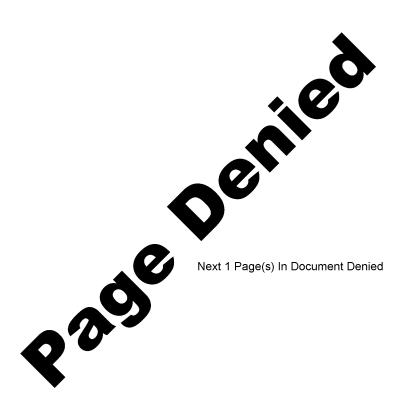
TEMPERATURE DEPENDENCE OF THE ELECTRON MEAN FREE PATH IN TIN AT LIQUID HELIUM TEMPERATURES

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To obtain detailed information on the electron mean free path in anisotropic metals the elaboration of a method for investigating separate groups of electrons is needed.

We made an attempt to use the method described in /1/ for investigating the temperature dependence of the mean free path of electrons in tin.

First of all it is necessary to give an exact definition of the quantity which is measured in experiments of this kind. If the constant magnetic field is inclined by a small angle to the surface of a single-crystal plate of thickness d it is possible to observe a series of peaks   STAT
in the curve of the dependence of the r. f. impedance upon the magnetic field. A peak occurs when the electrons in the vicinity of an elliptic limiting point on the Fermi surface make an integer number n of turns moving from one surface of the specimen to the other. The intensity of the effect depends on the amount of electrons which have been accelerated initially while moving in the first skin-layer parallel to   STAT
the surface of the sample and got into the skin-layer on the opposite side moving also along the surface.

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The selection of electrons according to the direction of their velocity is, therefore, made twice, at the beginning and at the end of the trajectory. Due to the scattering processes a part of effective electrons is removed (the refillment owing to the scattering of other electrons is negligible /2/). Because of the smallness of the skin-layer δ scattering by rather small angles is sufficient. The magnitude of this angle θ depends on δ/d, n and the angle φ between the magnetic field and the surface. The approximate evaluation gives $\theta \sim 10^{-3}$ assuming $\delta \sim 10^{-4}_{cm}$ (frequency $3 \cdot 10^6$ c.p.s.). The interaction with the phonon at helium temperatures scatters the electron by the angle of the order of p_{ph}/R, where p_{ph} is the phonon momentum and R is the radius of curvature of the Fermi surface. In our case $p_{ph}/R \sim 10^{-2}$. According to this estimation a single interaction with a phonon is sufficient to make an electron ineffective. The more it is correct for other scattering processes where the electrons are deflected by large angles. It was shown in /1/ that the amplitude A of the effect depends on the lengths of electron trajectories $s \sim d/\varphi$ as $e^{-s/\ell}$. It can be assumed that ℓ measured according to this formula corresponds to the path length between two elementary scattering acts.

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Experimental results

The amplitude A has been measured as a function of temperature for the elliptic point I (by the notation of /1/) situated at the Fermi surface near the direction $[100]$. This point is located presumably at the side-surface of the tube joining two corrugated planes in the fourth zone. the function $\frac{\varphi}{d} \ln A$ equals to $1/\ell(T) + C$ where C is an arbitrary additional constant. The limiting value of this function at $T \to 0$ can be defined by extrapolating with sufficient accuracy. The temperature dependence of the quantity $1/\ell(T) - 1/\ell(0)$ thus found is shown in Fig. 1 (logarithmic scale). The straight line drawn through the points corresponds to the law $T^{3.3}$ which is near to the Bloch's cubic law for electron-phonon scattering.

Because of the insignificance of electron-electron collisions in the temperature range under consideration these experimental results can be regarded as a confirmation of the idea that in our experiments the path-length between two elementary collisions was measured indeed and the scale of the ordinate in Fig. 1 represents $1/\ell_{ph}$, i. e. the probability of an electron-phonon interaction per unit of length. A small deviation from the cubic law is due presumably to the insufficient smallness of angle θ . Consequently the effectiveness of a single electron-phonon collision falls with decreasing temperature. In the case of d. c. conductivity of bulk specimens this leads to the well known

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law $\rho \sim T^5$ which is valid very well for tin at helium temperatures /3/. Our data can be compared to the evaluation of the electron-phonon path-length ℓ_T obtained from the heat conductivity data in the free electron approximation. According to the data of /4/ for tin $\ell_T \sim T^{-3}$ and ℓ_T is 10 - 20 times smaller than our value. This may indicate that at the investigated point of the Fermi surface the phonon scattering is considerably smaller than the average value over the surface.

References

1. V. F. Gantmakher, E. A. Kaner, Zhurn. Exp. Teor. Fys., 45, 1430, 1963.

2. M. Ya. Azbel, E. A. Kaner, Zhurn. Exp. Teor. Fys., 32, 895, 1957.

3. V. B. Zernov, Yu. V. Sharvin, Zhurn. Exp. Teor. Fys., 36, 1039, 1959.

4. N. V. Zavaritsky, Zhurn. Exp. Teor. Fys., 39, 1571, 1960.

Caption

Fig. 1. Surface of specimen is parallel to (010). R. f. electric field $\vec{E} \parallel [100]$. Constant magnetic field $\vec{H} \parallel (001)$. $\times$, $\varphi = 4°2'$; $+$, $\varphi = 2°45$; $\circ$, $\varphi = 3°10'$; $\bullet$, $\varphi = 4°15'$.